other method, is still in the experimental stage.

LEONARD P. KINNICUTT.
WORCESTER POLYTECHNIC INSTITUTE.

PHYSICS AT THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION.

THE meetings of Section B were held in the Middle Lecture Room of the Carnegie Institute. The first session of the Section on Monday, June 30, at 2:30 P.M., was taken up with the address of the retiring Vice-President, Professor D. B. Brace, on the subject 'The Group-Velocity and the Wave-Velocity of Light.' Tuesday afternoon the Section adjourned to inspect the Westinghouse works at East Pittsburgh. Wednesday morning was devoted to a joint session with the American Physical Society and Thursday noon the Section took a final adjournment for the Pittsburgh meeting.

The Section program was an unusually full one. Its forty-five titles, together with the fourteen on the program of the American Physical Society in joint session with Section B, may be roughly classified as follows: 23 were in the domain of electricity and magnetism, 22 in optics, 7 in thermodynamics, 4 in general mechanics and 3 in acoustics. The titles and a number of abstracts of the papers presented are given below. The papers were presented by the writers, except as otherwise indicated.

Contributions to the Theory of Concentration Cells: HENRY S. CARHART, University of Michigan.

The paper dealt first with concentration cells of the first class, in which two electrodes of one metal are immersed in a solution of a salt of the same metal, the density of the solution being different at the two electrodes. The Nernst theory requires that the direction of the E.M.F. within the cell be from the dilute to the concentrated solution. The author has discovered a cell in which the E.M.F. is directed the other way, viz., from the concentrated to the dilute solution. It consists of nickel electrodes immersed in solutions of nickel sulphate or nickel chloride.

The explanation given depended on the thermal E.M.F.'s at the two electrodes. Curves were exhibited showing that these E.M.F.'s increase with the density of the solution. In most concentration cells the thermal E.M.F. is from the metal to the solution; in nickel cells it is in the other direction. Hence the reverse direction of the E.M.F. of these cells. Application was made of these new facts to the explanation of the dependency of the E.M.F. of the Daniell cell on the density of the two solutions, and to the reversal of the temperature coefficient of the Daniell cell when the density of the zinc sulphate solution is only slightly over unity.

The paper next took up the other class of concentration cells in which the two electrodes are amalgams of a metal of different densities, the two amalgams being immersed in a single solution of the same metal. In these the thermal E.M.F.'s *increase* when the density of the amalgams *decreases*. The direction of the E.M.F. within the cell from the concentrated to the dilute amalgam is thus explained.

Further, since the thermal E.M.F. increases with the density of the solution, and decreases with the density of the amalgam, it should be possible to make a concentration cell with the denser amalgam in the denser solution and the weaker amalgam in the weaker solution, so that the E.M.F. of the cell would be zero. This has been found to be true.

Curves of thermal E.M.F. were shown for amalgams of different densities.

A preliminary paper will be published in the *Proceedings of the American Electrochemical Society.*

On the Complex Product of E.M.F., Current and other Vectors: H. T. Eddy, University of Minnesota.

The rules which govern multiplication and the other processes of ordinary algebra are those of mere number in its arithmetical sense. But algebra necessarily admits the use of complex numbers, to which arithmetical processes, such as multiplication, are perfectly applicable. Such complex numbers used as factors are not physical vectors, though they are frequently represented geometrically as quasi vectors.

When a physical vector, such as a force or a velocity, expressed in complex notation is multiplied by a mere numerical complex, the ordinary rules of algebra still hold. But when we multiply together two physical vectors expressed in complex form in order to obtain their product, the result has a physical significance which imposes laws of operation differing from those of ordinary algebra, and the factors are found to be non-commutative. The paper contains a detailed comparison of the nature of the two kinds of complex products, especially directed to the consideration of the product of pairs of alternating vectors of the same frequency, to show that the double frequency of such products does not arise in any way from the non-commutative character of the multiplication, as has been sometimes assumed.

Coefficients of Expansion between 0° and —190° C.: J. S. Shearer, Cornell University.

The coefficients of expansion for a number of metals at low temperatures have been measured by Dewar, using the method of weighing in liquid air. The writer has tried to get a method for the determination of the linear coefficients between 0° and —190° C. The method finally adopted was based on the idea of the compensated pendulum. By means of a combination of iron and cadmium, one end of the specimen was held fixed, while the other operated an optical lever.

This paper will later be published in full in the *Physical Review.*

A Set of Direct Current Dynamos arranged in Series for High Tension Work: G. S. Moler, Cornell University.

This paper describes, in detail, the installation at Cornell University of 24 small 500-volt dynamos connected in series. The machines are separately excited and give 0.22 ampère of current under an E.M.F. of 12,000 volts. This paper will later be published in full elsewhere.

Test of Liquid Air Plant at Cornell University: Frank Allen, Cornell University.

This plant consists of an electric motor, a compressor and a liquefier.

The compressor is of the four-stage type with air cylinders of about seven-, four-, two-, and one-inch diameter and of eight-inch stroke. Purified air is compressed by this machine to a pressure of 2,700 pounds per square inch.

In order to accomplish this a 500-volt electric motor of 30 horse-power is used, which has an efficiency of 87.6 per cent.

The apparatus used for liquefying air is known as the Hampson Liquefier, from the name of its English inventor. It works on the principle discovered by Lord Kelvin many years ago, that gases expanding from a high pressure to a low become slightly cooled. Air compressed to 2,700 pounds is allowed to flow through coils of copper tubing and issues at a low pressure from a small valve. The cool air circulates among the coils and cools the incoming air, which in its turn expands, lowering its temperature still more. This process goes on continuously and in about five minutes the

air is cooled enough to liquefy. The liquid air is collected in double-walled glass vessels with a vacuum between the walls.

In this test the power supplied during an hour was accurately measured, as was also the amount of liquid air obtained. By an expenditure of 25 horse power for one hour 2,919 grams of liquid air were produced. That is, the expenditure of one horse power per hour produces 116 grams of liquid air. The low temperature of the liquid air renders a certain amount of heat energy available. To vaporize one gram of the liquid requires 50 calories, or heat units. To raise the temperature of the gas from the boiling point of liquid air (—190° C.) to ordinary atmospheric temperature requires 47 calories more. The total amount required per gram is therefore 97 calories. For 116 grams there would be required 11,310 calories, or if the energy is expressed in mechanical units it amounts to 35,000 foot pounds.

In other words, the expenditure of one horse power continuously *for one hour* results in the production of just enough liquid air, which if it were utilized in its turn as a source of power in a *perfect* machine, the greatest amount of power obtainable would be one horse power *for one minute*. The most efficient method of obtaining liquid air as yet discovered, would increase this last period of time to *five minutes!*

The efficiency of the plant discussed in this paper was thus very low, being not quite two per cent.

The Theory of the Electrolytic Rectifier: K. E. GUTHE, University of Michigan.

The paper described the method of investigation and was illustrated by means of curves showing the relation between the current and the reaction, or polarization, or condensation voltage, with different metals and salt solutions.

Rayleigh's Alternate Current Phasemeter: E. S. JOHONNOTT, Rose Polytechnic Institute.

In the *Philosophical Magazine* for May, 1897, Lord Rayleigh has described a 'soft-iron galvanometer' which is quite suitable for measuring all quantities such as are ordinarily measured with ammeters, voltmeters and wattmeters. It consists of a soft-iron needle suspended between two parallel coils at an angle of 45° to their common axis. Besides furnishing a simple means for determining the phase relation in circuits, the instrument may be used as a wattmeter. Breslaurer has recently shown that it has advantages over the electrodynamometer used as a wattmeter on circuits having low power-factors.

Some experiments were undertaken with the instrument to determine the iron losses in choking coils where the power-factor was varied over a wide range by increasing the air-gap in the magnetic circuit.

Ordinarily the connections are similar to those for the wattmeter, the E.M.F. coil being connected across the terminals of the circuit and the other, the current coil, in series with the same. Another manner of using the instrument was found in practice to be much more simple and to give more consistent results. The connections for this method were the same as for Blakesley's split dynamometer. An exploring coil, exactly similar to the magnetizing coil, was wound on the magnetic circuit and connected in series with the E.M.F. coil of the phasemeter.

The instrument is as easily made as any simple form of galvanometer. The laws which connect the readings with the electrical quantities are perfectly similar to those of other alternate current instruments.

Many laboratory exercises, such as the determination of coefficients of self induc-

tion, phase angles and power, may be undertaken by the student with ease.

Measurement of the Intensity and Pressure of Radiant Energy: E. F. Nichols and G. F. Hull, Dartmouth College. Presented by Professor Hull.

This paper was supplementary to a paper on the same subject which was read at the Denver meeting of the American Association for the Advancement of Science in August, 1901. In the earlier paper it was shown that the 'gas action' due to a beam of light falling on a torsion radiometer had been approximately eliminated and that the 'light pressure' had been measured to the same degree of approximation; but that in the comparison of the experimental value of the light pressure with that deduced from the Maxwell-Bartoli formula, using the value of the energy as measured, a discrepancy of about twenty per cent. was found.

An analysis of the earlier work showed an error in the energy measurement due to an error in the resistance of the bolometer used. A new value of this resistance was found by the potentiometer method and by the application of theory to the determination of the resistance of a circular disc. The new value of the energy gave an agreement between the Maxwell-Bartoli formula and experiment, to about five per cent.

Later a more satisfactory method of measuring the energy was used, in which was observed the change of temperature of two thermojunctions of fine iron and constantin wire, placed inside a small silver disc upon which the radiation fell. The thermoelement was calibrated by immersing the silver disc in baths of kerosene at different temperatures. The average error in the measurement of the energy was considered to be less than one per cent.

By analysis of the earlier data on light pressure it was shown that the gas action had been eliminated approximately from the ballistic values, but was present in the statical readings. Later and more accurate experiments confirmed this result. The new value of the radiation pressure was found to agree with that derived from the Maxwell-Bartoli formula, using the new energy determination, to within a few per cent. For greater accuracy it will be necessary to measure the absorption and reflection coefficients of the surfaces used.

On the Penetration of Light into the Rarer Medium in the Case of Total Reflection: E. E. Hall, Cornell University. Read by title.

This paper will appear later in the *Physical Review.*

An Improved Form of Torsion Radiometer: E. F. Nichols, Dartmouth College.

A new radiometer case, somewhat larger than that of similar instruments earlier described, was shown. The advantage of the new form lies wholly in the support carrying the suspension, which is so designed that the length of the quartz fiber may be easily changed and the sensitiveness and period of the instrument altered through a wide range. All adjustments may be made without removing the suspension from the case, so that the danger of breaking the fiber is reduced to a minimum.

The Optical Properties of Iodine: W. W. Coblentz, Cornell University. Read by title.

The paper will appear in the *Physical Review.*

The Emission of a Righi Vibrator and the Measurement of the Length of Electric Waves by the Interferometer: H. R. Willard and L. E. Woodman, Dartmouth College. Presented by E. F. Nichols.

The paper dealt with the radiations emitted from a Righi vibrator which were studied in the first instance by resonance

effects on a Klemencic receiver, the length of which was varied. The curves bring out the existence of two upper partial vibrations or overtones; in some cases the third overtone also appears. The wave-length of the fundamental was later measured by the interferometer method. Further work on the same subject is in progress.

Some Experiments on Retinal Fatigue and Persistence of Vision: FRANK ALLEN, Cornell University.

The experiments were a continuation of some discussed in the *Physical Review*, Vol. XI., 1900, p. 257. It is a matter of common observation that when a person is some time in the dark the retina suffers 'adaptation,' which enables faint light to be more readily perceived. Some experiments were performed by the Nichols method of the measurement of the persistence of vision, to see how adaptation progressed with time. A normal measurement of the persistence of vision was made with the eye in its ordinary condition of adaptation for diffused daylight. Measurements were made after darkness adaptation of one-, three-, five-, ten- and fifteen-minute intervals. The results, when plotted with time intervals as abscissas and increases of persistence of vision as ordinates, give a curve much like a magnetic saturation curve. The measurements for fifteen minutes are practically the same as for five with all colors. Adaptation seems to be quite complete in five minutes. Longer intervals than fifteen minutes were not tried.

Experiments were next made in the same way by fatiguing the eye with light of various wave-lengths. Observations were made on the same wave-lengths as the fatiguing colors. The zero of reference was the normal persistence of vision with different colors; 'saturation' curves were obtained exactly as described above, the maximum fatigue being realized in three minutes with all colors.

The maxima of the curves differ, however. For wave-length .675μ the maximum is represented by 14. For yellow (.589μ) fatiguing has no effect. For green (.523μ) the maximum is 10. For blue (.470μ) no change of persistence occurs under the fatiguing stimulus of even ten minutes' exposure to the blue of an arc spectrum. In the violet (.430μ) the maximum is 20. These maxima, when plotted with wave-lengths as abscissas, give three elevations corresponding suggestively with red, green and violet.

The persistence of vision on the temporal side of the retina, ten and twenty degrees distant from the center, was measured. Throughout the spectrum the persistence diminished the further out the measurements were made. Some peculiarities were noticed in the part of the curve corresponding to the yellow region of the spectrum, connected doubtless with the 'yellow spot.'

The complete paper will appear in the *Physical Review*.

A Radiometric Receiver for Electric Waves: G. F. HULL, Dartmouth College.

The form of receiver for electric waves generally used in quantitative work is the Klemencic thermoelement. Here the dissipation of the energy into heat at the contact of two wires joining the two halves of the resonator gives rise to an electromotive force which causes a deflection of the galvanometer. In the form of receiver described in this paper this heat is made evident by the radiometric action on a very small vane of a torsion balance. Among the various receivers used the one so far giving the best results consists of two silvered strips of mica of the proper length for the waves used. These are divided at their centers by a very fine diamond scratch and are mounted vertically with

the center of each strip opposite a small vane. The whole system is placed in a bell-jar in such a way that the strips are in the focus of a parabolic mirror. The deflections are read by a telescope and scale. Owing to the lightness of the moving system (about 6.5 mgs.) and the efficiency of the method, the sensitiveness can be made much greater than that of the receivers of the Klemenčic design.

On the Efficiency of Window Illuminating Prisms: D. C. Miller, Case School of Applied Science.

The paper gave the results of photometric investigation of the distribution of light by prisms of various shapes, placed in different positions and operating with various sky conditions. The results are shown by distribution diagrams, from which are drawn conclusions as to the relative efficiencies under given conditions.

A Portable Photometer for Measuring Light Distribution: D. C. Miller, Case School of Applied Science.

The arrangement described is a special form of photometer which may be moved in any way, as about a pivot, for quickly measuring with moderate accuracy the relative intensity of light sent out in any direction from a source.

A Lummer-Brodhun screen is used to compare the light from the source with that from a standard illumination, the latter being capable of measured regulation from zero intensity to the maximum required.

The application of the photometer to the measurement of the distribution of light throughout a room, as by a window prism, was described.

Models for Explaining Polarized Light: D. C. Miller, Case School of Applied Science.

A description (with exhibit) was given of a series of original models for explaining double refraction, action of one Nicol prism and of two Nicols forming a polariscope; also for explaining the production of interference colors by a thin plate of a doubly refracting substance placed between crossed polarizer and analyzer.

A Model for Showing the Superposition of Two Oppositely Moving Wave-trains: W. S. Franklin, Lehigh University.

This model is designed for class-room demonstration and it consists of a large number of horizontal bars. One set of ends of these bars rests upon a wave-template and the other set of ends rests upon another wave-template. These two templates move in opposite directions at the same velocity. The middle points of the horizontal bars communicate to a row of points or balls the resultant motion of the two wave-trains.

The Just-Intonation Pianoforte of Dr. S. A. Hageman: H. T. Eddy, University of Minnesota.

Dr. Hageman has invented and constructed a pianoforte which will render the diatonic scale in perfectly just intonation in any key that may be desired. The piano differs in outward appearance from the ordinary piano simply in the fact that there is, in addition to the usual pedals, a bank of a single octave of pedals somewhat like organ pedals. These pedals actuate a bank of sliding bars on the back of the piano, which, in turn, move the bridges on which the piano strings rest, and adjust them simultaneously to any key desired by thus altering their effective lengths. It is believed that this cheap and exceedingly simple but perfectly effective device is the first practical solution of the problem of just intonation for instruments with fixed keys. The device is applicable to other instruments with fixed keys.

The piano is tuned in the usual manner in equal temperament and may be played in equal temperament also if so desired.

Contributions to the History of Musical Scales: CHAS. K. WEAD, Washington, D. C.

This paper was a summary of a research just published in the 'Report of the U. S. National Museum' for 1900. It described some forms of four-hole resonators found in various museums that give a pentatonic scale, whose notes have vibration frequencies following a square-root law; and various flutes and fretted string instruments were cited that show an equal linear division. The conclusion was that the primary principle of instruments capable of giving a scale is the repetition of elements similar to the eye; so the instrument is the first thing, the scale a secondary thing. Theoretic scales belong to a much later stage of culture.

The Present Significance of Enharmonic Musical Instruments: CHAS. K. WEAD, Washington, D. C.

These instruments may, in the hands of an artist, furnish a new point of view from which to judge of the development of music and its possibilities. But there is no evidence that any important music was ever composed in just intonation or that any of the many proposed or patented instruments are fitted to express the ideas of a composer. Certainly the diatonic idea which underlies such instruments is now far less important than when Helmholtz wrote, forty years ago.

Preliminary Note on the Effect of Percussion in Increasing Magnetic Intensity: GEO. F. STRADLING, Philadelphia.

When a rod of iron, steel or nickel has been magnetized and then demagnetized by the passage of a current of proper strength through the coil in which the rod is placed, tapping the rod causes the appearance of poles having the same direction as those existing before demagnetization. These poles, as the tapping continues, grow in strength to a maximum and then decrease.

If the demagnetizing current more than overcomes the original magnetism and produces poles in the opposite direction, still the effect of tapping is to make them first approach to those originally existing and then recede. In this case there are three stages produced by percussion:

1. Lessening of pole strength to zero.
2. Growth of pole strength in the direction existing before demagnetization.
3. Decrease of the strength of these newly acquired poles.

Whether percussion increases or decreases pole strength depends on the previous magnetic history of the body examined.

Preliminary Note on the Electrical Conduction of Saturated Powders: N. E. DORSEY, Annapolis Junction, Md.

The electrical conductivity of non-conducting powders saturated with electrolytic solutions was compared with the conductivity of the supernatant liquor. For coarse-grained powders the two are proportional, but when the powder is fine the conductivity of the saturated powder at first increases more rapidly than that of the supernatant liquor, with the result that for quite dilute solutions the conductivity of the saturated powder, as measured in a cubical cell, a pair of whose opposite sides served as electrodes, may even exceed that of a volume of the supernatant liquor equal to that of the solution in the powder as measured in the same cell.

Determination of the Vapor-pressure of Mercury at Ordinary Temperatures: EDWARD W. MORLEY, Cleveland, Ohio.

The writer has determined the vapor-pressure of mercury at intervals of ten de-

grees from 20° to 70°. A quantity of mercury was kept at a constant temperature, while a known volume of an inert gas was passed through in such a way as to become saturated with the vapor of mercury. From the loss of weight of the mercury, and the volume of the gas when at the temperature of the mercury can be computed the weight of vapor in unit volume, and the vapor-pressure.

Carbon dioxide was freed from accompanying hydrochloric acid by passing through sodium acid carbonate, and dried by phosphorus pentoxide. The mercury was contained in a spiral absorption apparatus. By a somewhat elaborate apparatus, a hundred liters of water were kept at a temperature constant within two or three hundredths of a degree. In an air-bath in this water were placed two absorption apparatus containing mercury. In one, gas passed at a rate of about thirty liters in a day, while the current was a third more rapid in the other. As both rates gave the same final values, it was thought that in both the gas had been saturated. The observed loss was always made as much as about ten milligrams; at the lower temperatures this required some twenty days.

Van der Plaats, in 1886, made determinations at 0°, 10° and 20°. About the same time the writer made determinations at 15°. All the observations, whether recent or older, are represented by the interpolation formula

$$\text{Briggs Log } P = -4 + 0.6020 + 0.02718\,T,$$

which gives the pressure in millimeters of mercury. The greatest difference between observation and formula is 0.0008 mm. and the mean difference is 0.00025 mm. The extrapolation formula of Hertz agrees with observed values at 20°, but is in excess by thirty per cent. at the higher temperatures; the formula of Ramsay and Young agrees with observation nearly as well.

On the Feasibility of Transmuting Terrestrial Heat into Available Energy: JACOB WAINWRIGHT, Chicago.

This paper has been published privately by the author.

On the Conditions Controlling the Drop of Potential at the Electrodes in the Vacuum Tube Discharge: C. A. SKINNER, University of Nebraska.

The paper was presented by Professor Zeleny and will later be published in the *Philosophical Magazine.*

The drop of potential at the electrodes is supposed to be due to the difficulty of the carriers to give up their charges to the metal on account of the velocity of impact.

This velocity must first be reduced, which is done by repeated bounding away from the electrode, the coefficient of restitution being taken as less than one. An equation was obtained for an ideal simplified case for the time required for the carrier to be brought to rest. The longer this time, the greater is the fall at the electrode on account of the accumulation of the carriers at the surface.

Experiments in which some of the quantities involved were varied gave results in harmony with the above view of the cause of the drop at the electrodes.

On the Rotary Dispersion of Fuchsine Solutions: F. J. BATES, University of Nebraska. Read by title.

Sparking Potentials for Small Distances: E. EARHART, Rose Polytechnic Institute. Read by title.

On the Magnetic Behavior of Nickel-copper and Nickel-tin Alloys: BRUCE V. HILL, University of Nebraska. Read by title.

Some Observations Showing the Oscillatory Character of Lightning: A. W. SMITH, University of Mississippi. Read by title.

On the Effect of Electrolytic Condensers in Alternating Current Circuits: A. TROWBRIDGE and E. R. WOLCOTT, University of Wisconsin.

The paper was presented by Professor K. E. Guthe and described in detail phenomena observed in electrolytic condensers used in alternating-current circuits. It was shown that the custom of regarding such condensers as two ordinary condensers in series was erroneous, as such a view is inadequate to account for the enormous capacities observed. The paper will be published in full elsewhere.

On the Accuracy of the Zero in a Dynamophone: J. BURKITT WEBB, Stevens Institute of Technology.

Presented by Professor B. F. Thomas.

The dynamophone is a new dynamometer in which the energy transmitted per revolution is measured by the twist of the shaft transmitting it, said twist being measured while the shaft is in motion by an electrical method in which no contact is made with the shaft.

It consists of two armatures or toothed wheels mounted on the shaft at a sufficient distance from each other, each wheel having a telephone magnet with its coil mounted in front of it in such a way that it can be revolved about the shaft. The distance of the telephone magnets from the armatures is also adjustable. These two telephones are connected in series with a receiving telephone which, when the two telephones are properly adjusted to opposite phases and equal amplitudes, gives no sound or indicates *zero*. When the shaft twists under the transmission of a moment the observing telephone must be revolved through the angle of twist to obtain the *zero* or opposition of phase.

As in some cases the observing magnet can be revolved through a small angle without perceptibly altering the zero, it is advisable to discuss the accuracy of the same, regarded as a question of the interference of waves of the same period with slightly different overtones, and to use a method of observation which avoids the difficulty to a great extent.

Absorption of Salts in Aqueous Solutions by Powdered Quartz: LYMAN J. BRIGGS, Washington, D. C.

Finely divided quartz when shaken up with an aqueous solution of a salt possesses the property of increasing the concentration of the solution in the region immediately outside of the solid particle, thus decreasing the concentration of the free solution. Quantitative results showing the relation between concentration and amount of absorption have been obtained for carbonates, hydroxides and chlorides of sodium, potassium and ammonium.

(*a*) The absorption of the acid radical was found to be independent of the base.

(*b*) The amount of absorption is not a linear function of the concentration, but is relatively greater for dilute solutions.

On the Osmotic Pressure of Absorbed Salts: LYMAN J. BRIGGS, Washington, D. C.

Osmotic pressure of absorbed salts must be the same as in the free portion of the liquid, if equilibrium exists. But the concentration of the absorbed layer is greater than in the free solution. Therefore, the osmotic pressure of the absorbed layer is not proportional to the concentration of that part of the solution.

On the Rapid Filtration of Turbid Solutions and the Change in Concentration Produced by the Porous Septum: LYMAN J. BRIGGS, Washington, D. C.

This paper, which will appear in Bull. 19, Bureau of Soils, U. S. Department of Agriculture, was read by title.

On the Formation of Dew Bows: Lyman J. Briggs, Washington, D. C.

A description was given of the formation of a prismatic bow caused by the reflection and refraction of light from drops of dew supported on extremely fine spears of grass.

Note on a New Form of Laboratory Switchboard Jack: F. C. Caldwell, University of Ohio.

This form of jack, which has proved very successful, is made up of one or more brass tubes with a shoulder at one end and threaded at the other, so that an ordinary nut screwed on will hold the jack in the board. Where opportunity for inserting two or more plugs is required, these jack tubes are united by yokes on the back of the board. Ten of these jacks after several months' use averaged six-thousandths-volt drop when carrying 100 ampères. The plug for this jack is a straight piece of three-eighths-inch rod slit at the end and fastened in a handle. The cost of such a single jack with nut, washer and plug complete is trifling.

Note on a New Variable Ironless Induction Coil for Large Currents: F. C. Caldwell, University of Ohio.

This coil is interesting because of its large size. It is made up of two concentric coils, one swinging within the other. Its resistance is 1.4 ohms, and its impedance, with sixty period current, about forty ohms. It is wound with ten layers of twenty turns of No. 8 wire in the outside coil, and nine layers of twenty turns in the inside layer. About one hundred pounds of wire was used in the construction. The outside diameter of inside coil is twenty inches.

On Molecular Friction in Steel and Phosphor-Bronze: J. O. Reed, University of Michigan.

The method consisted in observing the time required for a tuning fork to diminish its amplitude of vibration from one fixed amplitude to another, the tuning fork being enclosed in a chamber heated electrically, and the amplitudes being observed by a telescope. This period of time becomes a minimum at about 70° C. and then increases again. The diminution in amplitude was assumed to be due chiefly to molecular friction.

Young's Modulus for Phosphor-Bronze, Between 20° and 300° C.: J. O. Reed, University of Michigan.

The phosphor-bronze was in the form of the tuning fork of the last paper and it was heated in the same chamber. The paper described the additional appliances necessary to measure Young's modulus. The results obtained were given.

A Photographic Study of the Alternating Arc: G. A. Hoadley, Swarthmore College.

An alternating arc was observed under the following conditions: (*a*) Between carbon points, ordinary; (*b*) between carbon and zinc points, showing that there is an illuminating arc only once per cycle, and that there is a direct current passing from zinc to carbon in the arc, which can be read by a direct-current ammeter; (*c*) between carbon points in a magnetic field showing the alternating direction of the current; (*d*) between carbon points, the lower of which is double, showing that two direct-current ammeters placed in the lower branches will show two direct currents if placed in opposite directions.

The Nernst Lamp: A. J. Wurts, Pittsburgh, Pa.

Mr. Wurts gave a very interesting account of the technical evolution of the Nernst lamp in this country, mentioning many of the defects in the original which had been overcome by the ingenuity of American engineers. The lamp in its pres-

ent form was exhibited and the functions of its various parts explained.

Absorption Spectra of the Permanganates: B. E. MOORE, University of Nebraska. Read by title.

The Index of Refraction and the Absorption of Fuchsine: W. B. CARTMEL, University of Nebraska. Read by title.

Determination of Dispersion by Means of Channeled Spectra: S. R. WILLIAMS, University of Nebraska. Read by title.

E. F. NICHOLS,
Secretary Section B.

SECTION B.

IN SESSION WITH THE AMERICAN PHYSICAL SOCIETY.

The meeting was held in the Middle Lecture Room of the Carnegie Institute, July 2, 1902. Professor W. Le Conte Stevens was elected chairman *pro tem.* The program follows:

Results of Recent Magnetic Investigations: L. A. BAUER, U. S. Coast and Geodetic Survey, Washington, D. C.

The paper was illustrated by charts which exhibited the results of recent researches in terrestrial magnetism conducted by the U. S. Coast and Geodetic Survey. Several recording magnetic instruments of modern construction were described and methods of standardization discussed. Lantern slides of the new magnetic observatories of the survey were shown.

Some Recent Interesting Magnetic Disturbances Registered at the Coast and Geodetic Survey, Magnetic Observatories: L. A. BAUER.

The records of a number of recent magnetic disturbances taken at the different magnetic observatories of the Coast Survey were shown by lantern slides and the significance of the results obtained was discussed. Both of the foregoing papers will appear in the *Journal of Terrestrial Magnetism and Atmospheric Electricity.*

On the Relation between Thermoelectric Power and Change of Length, caused by Magnetization: EDWARD RHODES, Haverford College.

A thermoelectric pile of fourteen iron wires, 40 cm. long, thirteen copper wires, 15 cm. long, and one bar of a special alloy of antimony and zinc, was built up. The alloy has the property that its thermoelectromotive force with iron is such as to counteract that of the thirteen copper iron junctions.

When this pile has steam and cold water jackets placed over its ends and is inserted in a suitable solenoid, a curve may be obtained showing the thermoelectric power, at the mean temperature, of magnetized, against unmagnetized iron, as the field is varied.

A cyclic curve of this kind was taken and proved to be of the peculiar and distinctive type of the cyclic change of length curves.

In order that the two curves should agree, however, it is necessary to correct the change of length curve for the contraction $B^2/4\pi Y$, where Y is Young's modulus.

A similar thermopile was constructed of nickel wires. In this case only the first ascending branch of the curve was taken. This was of the same type as the change of length curve for nickel, which is altogether different from that for iron.

The existence of this relation seems to open the way to a large amount of further work on the nature of magnetism.

The complete paper will appear in the *Physical Review.*

Experiments on the Electrolysis of Radioactive Solutions: GEO. G. PEGRAM, Columbia University. Read by title.

Absorption Spectrum of Carbon: E. L. Nichols and E. Blaker, Cornell University. Presented by Dr. Blaker.

The selective radiation of carbon has already been shown. A further series of experiments have been made during the past year on the selective absorption of carbon. Deposits have been obtained by deposition on glass in vacuum tubes between terminals of carbon, in series with the secondary of an induction coil, the residual gas being acetylene. These deposits vary in composition without doubt, and show different absorption for different conditions of deposition, depending on the pressure of the residual gas.

Deposits made on platinum by 'flashing,' as in the ordinary incandescent lamp, and then transferred to glass and studied with the spectrophotometer, show the same peculiarities as have been shown to be obtained using glowing treated carbon. The dispersion has not been fully studied yet.

The paper will be published in the *Physical Review.*

Persistence of Vision in Color-blind Subjects: Frank Allen, Cornell University.

In this investigation, color-blind subjects were studied by the Nichols method of the measurement of the persistence of visual impressions. A sectored disc was rotated in front of the slit of a spectrometer at such a speed that the flickering of the part of the spectrum under observation just became imperceptible. The speed at this instant was electrically recorded on a piece of paper carried on a chronograph cylinder.

The measurements when plotted as ordinates with wave-lengths as abscissas form a 'persistency curve' which is parabolic in shape, convex toward the axis of abscissas, and with the apex at the *D* line. Under the same conditions of brightness of the spectrum and adaptation of the retina the persistency curve is invariable for the same subject and even for persons of about the same age, providing their color vision is normal. Color-blind persons obtain persistency curves which usually coincide with normal curves in part, but which always have one or two elevations. The positions of these characteristic elevations afford a means of classification; for they occur only in the parts of the curve corresponding to the red, green and violet of the spectrum.

The Young-Helmholtz theory postulates three fundamental color sensations—red, green and violet. In color-blind subjects it may be expected that any one of these may be absent or modified alone, or that any *two* may be absent or modified, or that all three may be absent. The last phenomenon is that of total color-blindness, and its existence is not provided for by the Young-Helmholtz theory, apart from total blindness. There are thus seven possible types of color-blindness, and in this investigation persistency curves corresponding to six of them have been obtained, the missing one being that in which an elevation is to be expected in the violet end of the curve. One case of total color-blindness is also described which is remarkable in that the brightest part of the spectrum is in its normal position to him. No similar case has yet been described.

In this research twenty-six cases of color-blindness were examined, and their results permit a very complete and systematic classification, such as is obtained by no other method. The conclusion reached is that the fundamental sensations are red, green, violet and white. The assumption of more than these three color-sensations is strongly opposed by these experiments.

Heat of Vaporization of Liquid Air: J. S. Shearer, Cornell University.

This paper will appear in the *Physical Review.*

The Magnetic Field Produced by a Flight of Charged Particles: R. W. WOOD and HAROLD PENDER, Johns Hopkins University. Read by title.

Note on the Thermal Unit: H. T. BARNES, McGill University. Read by title.

On the Action of a Condenser in an Induction Coil: J. E. IVES, University of Cincinnati. Read by title.

Note on a Graphical Method for Tracing Rays Through Optical Prisms: WILLIAM FOX, College of the City of New York. Read by title.

On a New Half-shade Polariscope: D. B. BRACE, University of Nebraska.

An Explanation of the Faraday and Zeeman Effects: D. B. BRACE. Read by title.

Additional Notes on the Construction and Use of the Brace Spectrophotometer: S. B. TUCKERMAN, University of Nebraska. Read by title.

E. F. NICHOLS,
Secretary pro tem.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

THE tenth annual meeting of the Society was held at the Carnegie Institute, Pittsburgh, Pa., on June 27 and 28, 1902. The attendance was larger than at any meeting since 1898 and the interest was so well maintained that the attendance at the four sessions did not vary ten per cent. Thirty-four applicants were elected to membership, making the total 287.

At the opening session the members were deeply grieved at the announcement by the President of the sudden death of Professor John Butler Johnson, Dean of the College of Engineering, University of Wisconsin, the notice of which appeared in the Pittsburgh press the evening before. Professor Johnson was one of the founders of the Society, a past president, and its first secretary. His enthusiasm, influence and active work for the Society were prominent factors in its development and usefulness, and he expected to be present at the Pittsburgh meeting, and, as usual, to take part in the discussions.

After the transaction of general business the President, Professor Robert Fletcher, Director of the Thayer School of Civil Engineering, read his address on 'The Efficiency Factor in Engineering Education.' After referring to the object of the Society an analysis of the membership was given which showed that 10 per cent. are practicing engineers who are not teachers, about 18 or 20 per cent. are both teachers and practitioners, 45 to 47 per cent. are teachers only or chiefly in civil, mechanical, electrical, mining and other departments of engineering, about 3 per cent. are identified mainly with instruction in pure technics, such as manual training, etc., while about 21 per cent. give the indispensable and fundamental preparation in mathematics, mechanics and the physical sciences. Another division gives 33 per cent. as committed to civil, 22½ per cent. to mechanical, 11 per cent. to electrical, and 9½ per cent. to mining and other branches of engineering. The balance of 24 per cent. constitute the teachers in preparatory courses and the practicians. An analysis was then made of the character of the 179 papers and reports by members and committees, respectively, which, together with the discussions, are printed in full in the nine volumes of *Proceedings*. Attention was called to the distinction between engineering and technology and the inconsistencies between the titles and performances of many engineering and technical colleges or schools.

The factor of efficiency in engineering education was regarded as influenced and